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ABSTRACT

Presented is a science activities in energy package which includes 12 activities relating to solar energy. Activities are simple, concrete experiments for fourth, fifth, and sixth grades, which illustrate principles and problems relating to energy. Each activity is outlined on a single card which is introduced by a question. A teacher's supplement is included. (SL)

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SCIENCE ACTIVITIES IN ENERGY

Science Activities in Energy is a series of simple, concrete, revealing experiments that was developed by the American Museum of Atomic Energy especially for fourth, fifth, and sixth graders but can be just as useful in community programs.

The purpose of the series is to illustrate certain principles and problems related to various forms of energy and to their development, use, and conservation.

More important, it is an effort to help you and other teachers involve students directly in exploring intriguing questions—in making discoveries on their own.

You needn't be an expert in science to use this material. In fact, teachers shouldn't be expected to know the "right" answer to every question posed. What's more, many of the activities involve not just science but art, economics, arithmetic, reading, and other skills and disciplines as well—and need not be used in sequence.

Each unit in the series forms a coherent program of instruction on a single topic: solar energy, electricity, conservation, and the like.

Most activities in the series can be completed in the classroom with materials readily available in any community: pots and pans, paper cups, water, salt, thermometers, and cardboard boxes. A few require purchases from local or national suppliers.

Each project is introduced as a question: How much warmer do objects get in the sun than in the shade? What is the best color to paint a house to keep it cool in the summer? Which stores solar energy better—water or rock?

At the outset of an experiment, try to get your students to predict outcomes, even when they have no experience to justify their projections. Urge them to make a guess. They'll become more interested, feel more involved, if they do.

In order to answer each question, a student (or the class as a group) follows instructions on an activity card that lead him or her through a specific experiment.

This kind of direct student participation leads easily to other related questions—some suggested on the activity cards themselves, others generated by the students and their teacher—and to further exploration by the experimenters on their own.

The American Museum of Atomic Energy has purposely used metric measurements throughout the experiments, believing that this would be part of the learning process for many young people and for some adults as well.

Because the activities are outlined on single cards, you can easily photocopy them for distribution or project them on a screen or wall.

As the developers of the series, we are anxious to learn how you and your students use the materials, what variations you develop, and any results you find extraordinary. Please let us know your reactions to the materials, and feel free to ask for more information on any energy-related topic.

SOLAR ENERGY

Anyone who has had a sunburn, walked through a greenhouse, hung clothes on the line to dry, or watched spring arrive recognizes the power of the sun. In a one-to-two week period, the sun transmits more energy to the earth's surface than all of the energy stored in the earth's known reserves of coal, oil, and natural gas. And each year more than 500 times as much energy is radiated from the sun to the surface of the United States as we consume in all conventional forms of energy.

The sun is the most inexhaustible and the cleanest source of energy known. Its heat and light arrive week in and week out—free. But not in uniform amounts each day, or in concentrated form, and not at all at night. Consequently, the barriers to greater use of solar energy by a world faced with dwindling energy resources are significant: mainly, diffusion and the inability economically to store solar energy, use it directly, or convert it to electricity.

Activities in this series cover some of the problems and some of the possible solutions.

The series, **Science Activities in Energy,** was developed by the Oak Ridge Associated Universities under contract from the U.S. Department of Energy, with assistance from teachers and staff from the Lawrence Hall of Science, Berkeley, California. This publication was prepared as an account of work sponsored by the United States Government. Neither the United States nor the U.S. Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

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HOW MUCH CLEAN WATER CAN THE SUN GET OUT OF A PAN OF MUDDY WATER IN A SINGLE DAY?

1

MATERIALS:

- Large pan or tub
- Clear plastic food wrap
- Rock
- Masking tape
- Muddy water
- Drinking cup or glass

Fill a pan to a depth of 5 cm with muddy water.

Then, do this:

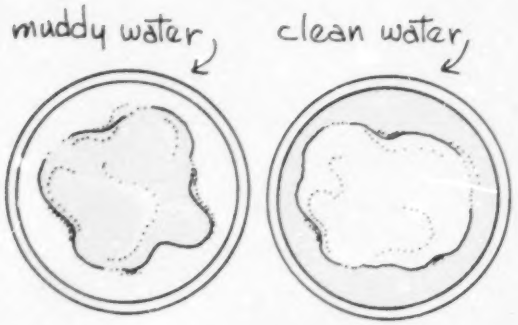
Place the drinking cup in the middle and cover the pan with clear plastic. Tape the plastic firmly!

Put a rock on the plastic wrap to make it sag in the middle, but don't let the rock touch the cup!

As the water evaporates, notice the tiny drops that condense on the cool plastic wrap.

OTHER IDEAS TO EXPLORE:

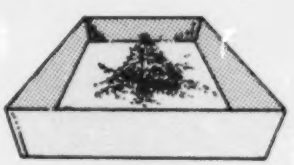
Try this experiment with salty water. Do you get more clean water than from muddy water? Is this a good way for your city to get pure water to drink? From this experiment does it look like mud evaporates?



Check to see how clean your water is by placing several drops of muddy or salty water on the curved bottom of a plastic cup. Do the same with a few drops of clean water. After the water evaporates from both cups, notice if any residue is left behind.

Try making salt by evaporating seawater. In a large flat pan, pour a measured amount of seawater. Allow it to evaporate. Keep adding measured amounts until the salt forms crystals. Weigh the dry salt. How much seawater did it take?

To make seawater- add 1 teaspoon salt to 1 cup water!



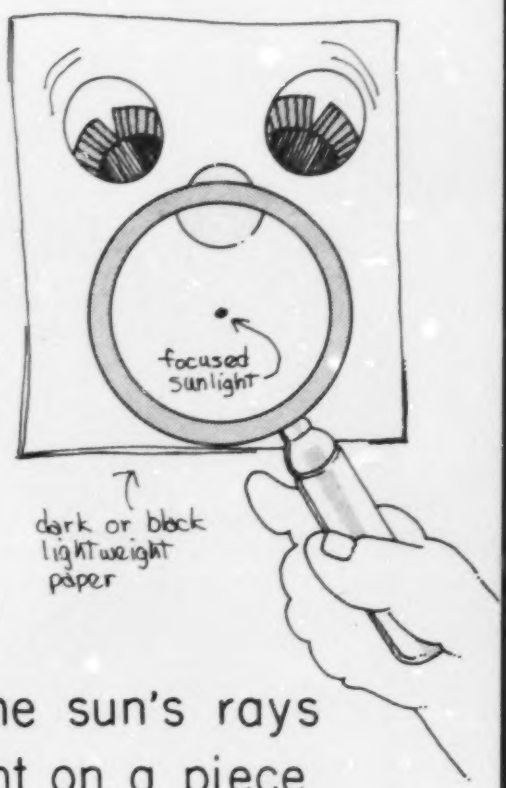
HOW MUCH FASTER CAN YOU BURN A PAPER WITH A 6cm MAGNIFIER THAN WITH A 3cm MAGNIFIER ?

2

MATERIALS:

(1" = 2½ cm)

- 1 6cm (or larger) magnifer
- Paper and scissors
- Watch
- 1 Sheet heavy black construction paper
- 1 Sheet dark or black lightweight paper

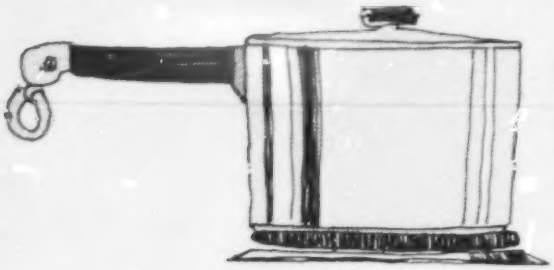


Position the magnifying glass so the sun's rays focus the smallest amount of light on a piece of dark or black lightweight paper. How many seconds does it take before the paper starts to smoke? (Be careful - it gets hot!)

Now cover the lens with a piece of black construction paper that has a 3cm hole cut in the center. How long does it take this time?

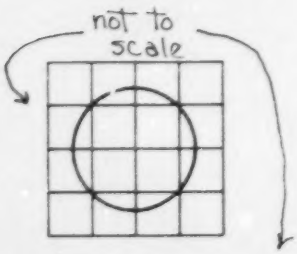
Try it with different colors of construction paper!

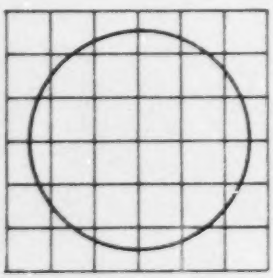
OTHER IDEAS TO EXPLORE:



Do you think you could boil water this way?

Solder melts at a low temperature for metal. Do you think you could melt solder?





Do you think a glass container filled with water might do the same thing as your magnifying glass?

How much more sunlight does the 6 cm lens let in than the 3 cm lens? Draw one circle that is 6 cm wide and one that is 3 cm wide. Now draw grids over these circles on a 1 cm scale. Count the number of squares and parts of squares that each circle covers. What's the total?

Does this explain your results? Would this exercise be more accurate if your grid was on a 1/2 cm scale?

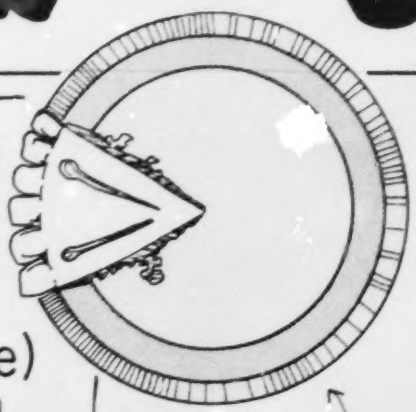
IN COLLECTING SOLAR ENERGY, IS BIGGER BETTER?

3

MATERIALS:

- Large disposable pie plate
- Small disposable pie plate
- Black paint (not water soluble)
- Candle
- Thermometer
- Measuring cup
- Clear plastic food wrap
- Newspapers, styrofoam cups
- Masking tape, water

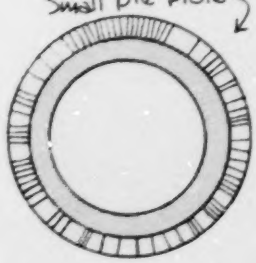
Remove any remaining pie before painting pie plate →



Large pie plate

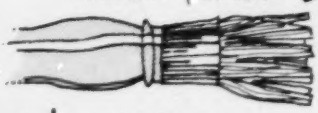
Paint both pie plates black!

Small pie plate



When the paint dries add 100cc of water to each pie plate and wrap plastic wrap tightly around them - tape in place!

Paint brush. What would happen if the pie plates weren't painted? →



Do this first:

Place each on a stack of newspapers in the sun for 10 minutes.

← newspapers serve as insulation - why is this important?

Now pour the water into styrofoam cups and measure the temperatures.

OTHER IDEAS TO EXPLORE:

This is a magic pie plate - it floats! But yours won't - how will you suspend it over the candle?

Refill the large pan and this time heat to the same temperature as before using a candle. How much did the candle cost? How much did the solar energy cost? What are the advantages of each?

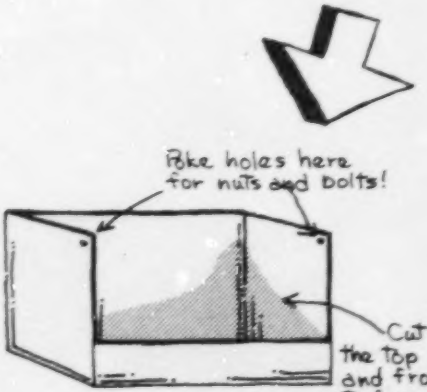
Is solar energy free?

HOW LONG DOES IT TAKE TO COOK A WITH THE SUN? 4

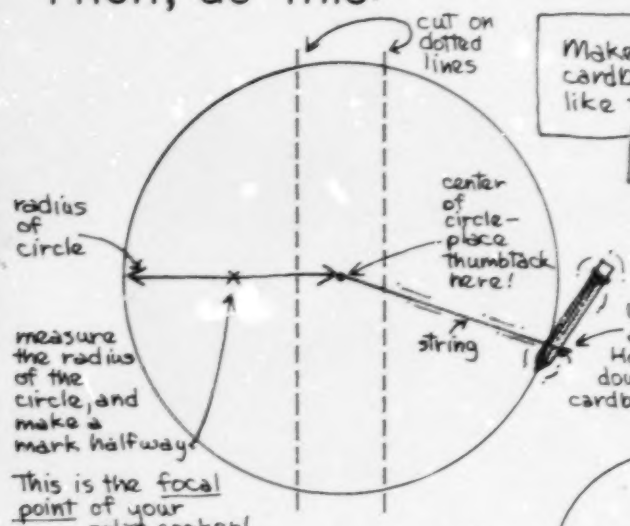
MATERIALS:

1 Hot dog
Cardboard boxes
Aluminum foil
Coathanger, thumbtack, string, pencil
2 Small nuts and bolts
Rubber cement

Do this first:



Then, do this:


cut on dotted lines
radius of circle
center of circle - place thumbtack here!
string
measure the radius of the circle, and make a mark halfway!
This is the focal point of your solar cooker!

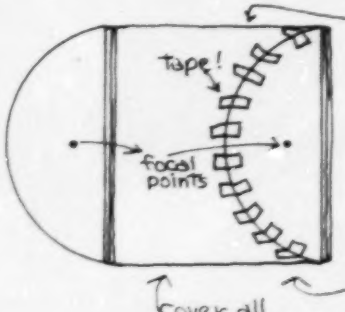
Make 2 large cardboard circles like this:

Use the string to hold the pencil, and attach the other end to the thumbtack. Hold the pencil tightly, straight up and down, and draw a circle on a piece of cardboard! Then, cut apart as shown.

Now, glue 2 pieces together to make 1 that's twice as heavy!

Do this with both circles you cut-

Now, put the 2 curved pieces together like this:



Tape another piece of cardboard to the curved edges of the 2 half circles you glued together -

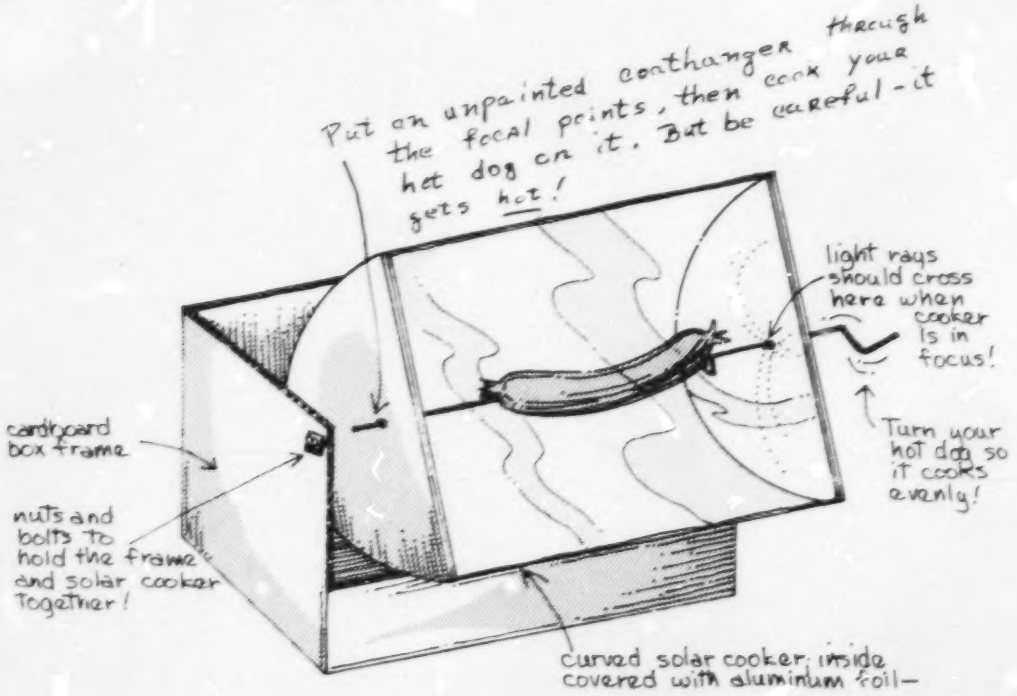
the width of the piece of cardboard should be slightly less than the width of the box you cut to make a frame!

Then, cover the inside of this piece with aluminum foil - use rubber cement!

Cover all of inside with aluminum foil!

over

Adjust the cooker so that you can see the sun's rays cross on the focal points. How long does it take to cook a hot dog ?

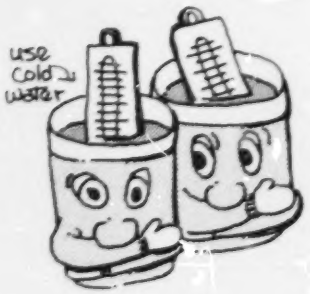

Put an unpainted coathanger through the focal points, then cook your hot dog on it. But be careful - it gets hot!
light rays should cross here when cooker is in focus!
Turn your hot dog so it cooks evenly!
cardboard box frame
nuts and bolts to hold the frame and solar cooker together!
curved solar cooker inside covered with aluminum foil

HOW MUCH WARMER DO THINGS GET IN THE SUN THAN IN THE SHADE ?

5

MATERIALS:
- 2 Styrofoam cups
- 2 Thermometers
- Watch

Pour equal amounts of cold water into 2 styrofoam cups. (the colder the better!)



Place a thermometer in each cup.

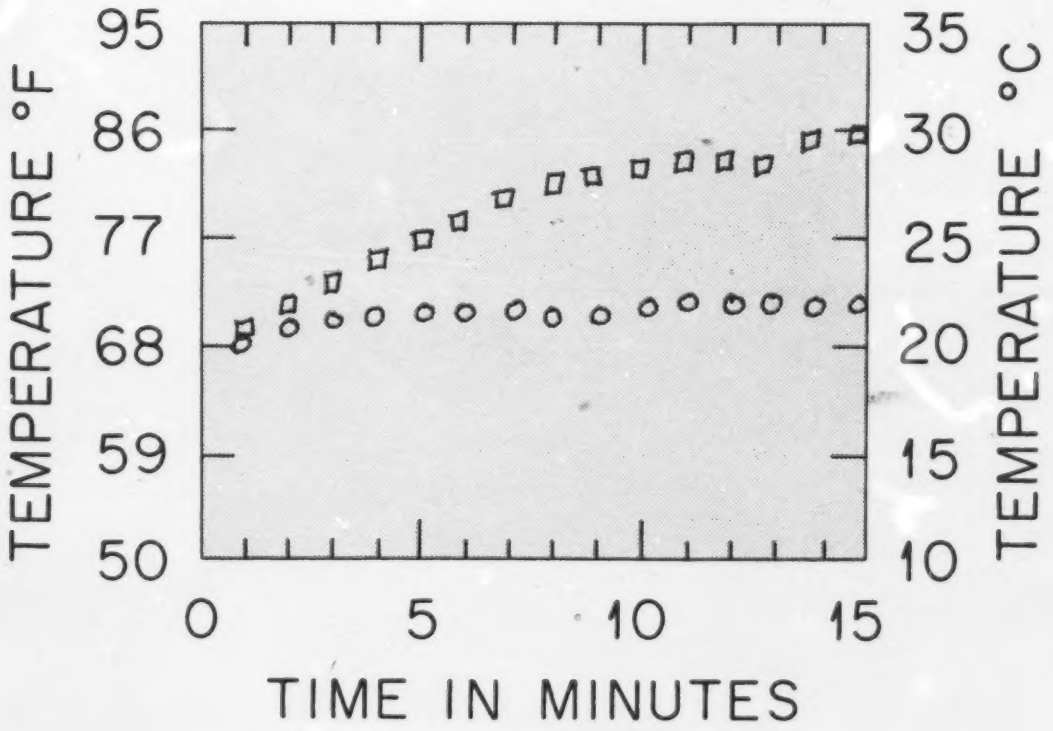
Set one in the sun and the other in the shade.

What is the temperature of each after 5, 10 and 15 minutes ?

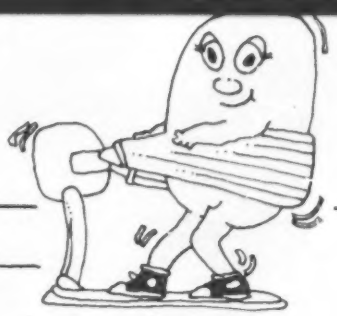
OTHER IDEAS TO EXPLORE:

Make a graph like the one below, and use it to record the temperatures each minute for 15 minutes. Use different markers for each.

Would the water in the cup get warm on a cloudy day? On a cold but sunny day?



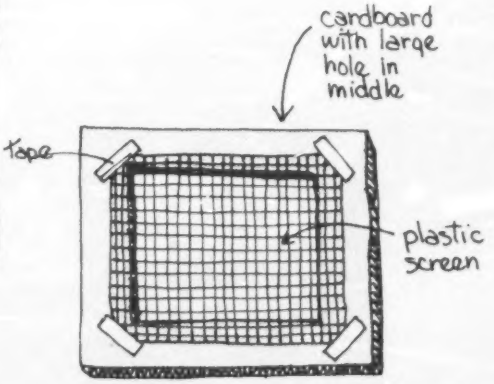
HOW MUCH WEIGHT CAN A GRAPE LOSE IN A WEEK?



6

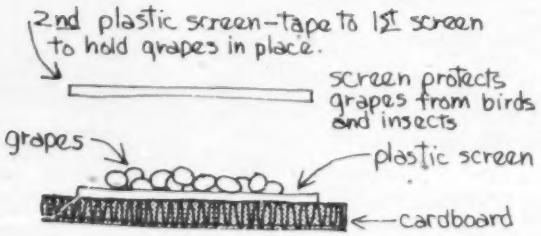
MATERIALS:

- 1/4 lb. Grapes
- Plastic window screen (from hardware or variety store)
- Cardboard, masking tape
- String, food scale



Do this first:

Weigh the grapes.
Then, do this.

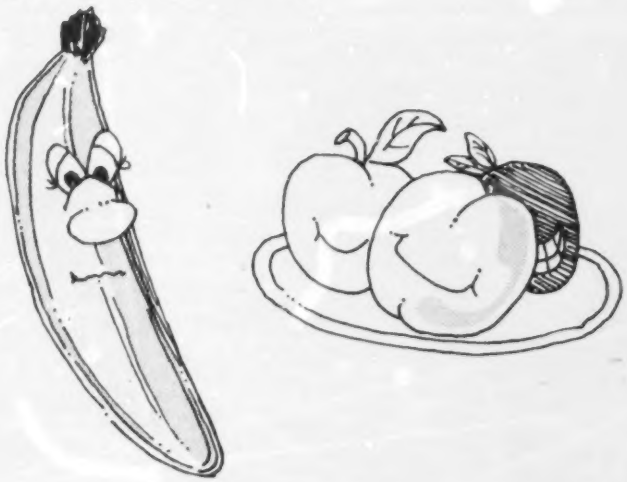

2nd plastic screen–tape to 1st screen to hold grapes in place.
screen protects grapes from birds and insects
grapes
plastic screen
cardboard

Hang with string in a sunny spot during the daytime.

When the grapes look like raisins, remove them and weigh again.

OTHER IDEAS TO EXPLORE:

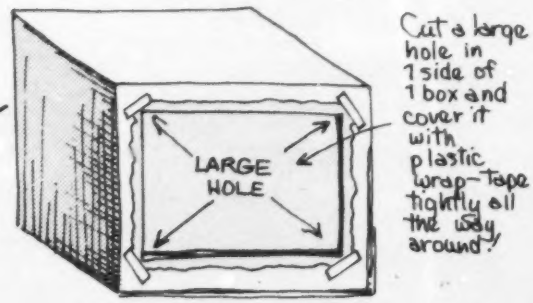
Many fruits can be dried in this way. Apricots, prunes, and peaches are especially good. If fresh apricots are 59¢ a pound and dried apricots are $2.00 a pound, which is a better buy?



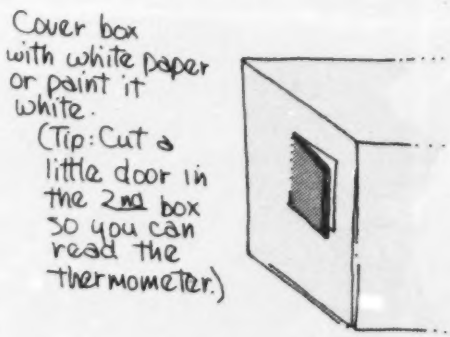
HOW MUCH HOTTER DOES A HOUSE GET WHEN THE WINDOWS FACE SOUTH INSTEAD OF NORTH?

MATERIALS:

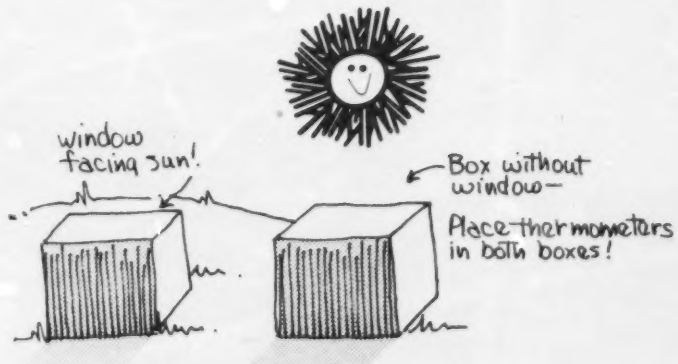
- 2 Cardboard boxes of same size
- White paint or paper
- 2 Thermometers
- Plastic wrap
- Masking tape



Paint both boxes white, or cover them both with white paper.



Place a thermometer in each box and put them in the sun.



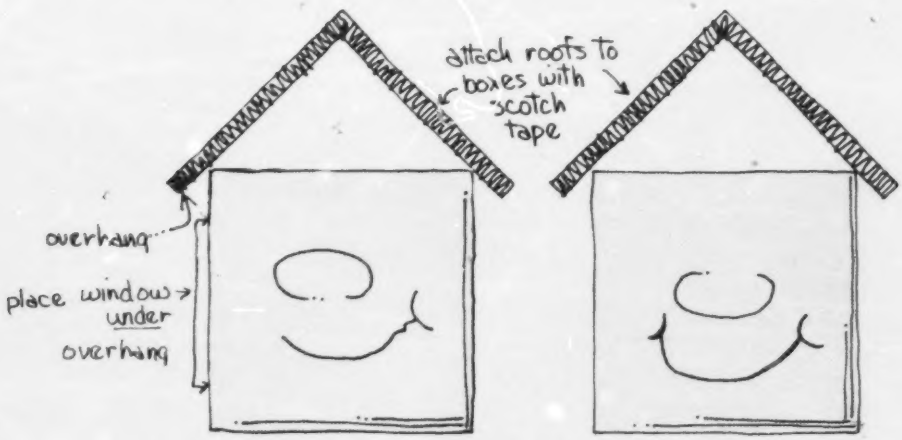
Record the temperatures after 10 minutes, 20 minutes, and 30 minutes. What do you find?

OTHER IDEAS TO EXPLORE:

Try this experiment at different times during the day.

Does this make any difference?

Add an overhang to both boxes:
Does this make any difference? How would the overhang affect this experiment at different times of the year?



Try cardboard overhangs of different sizes to see if it makes a difference.

WHAT COLOR ABSORBS THE SUN'S HEAT BEST ?

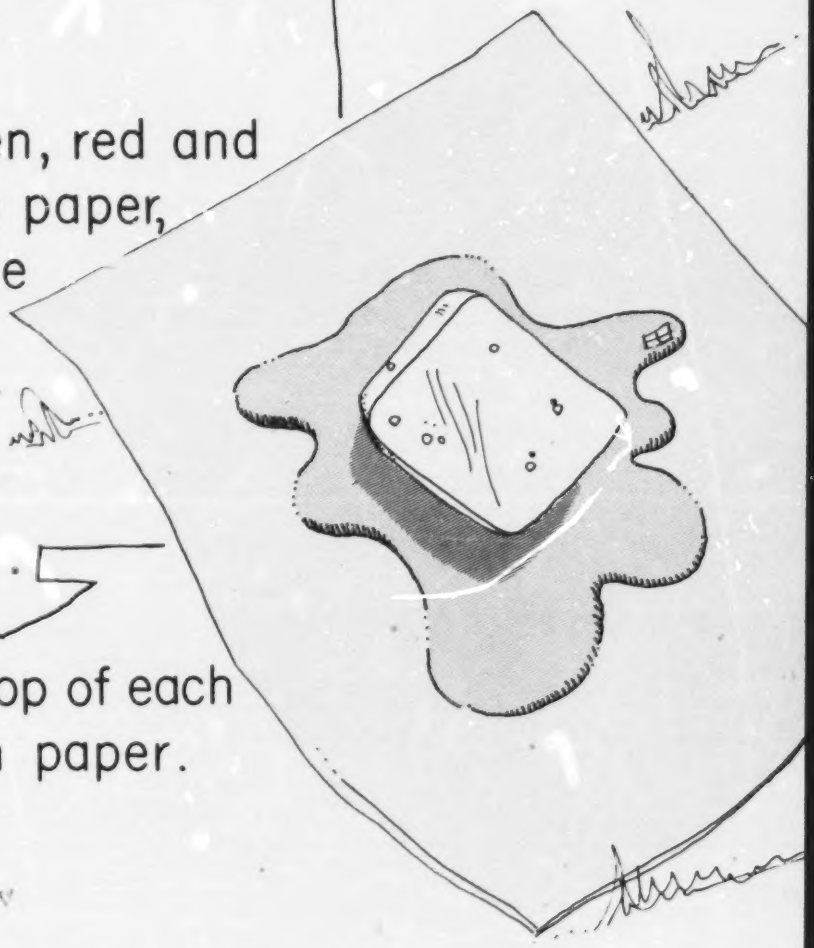
8

MATERIALS:

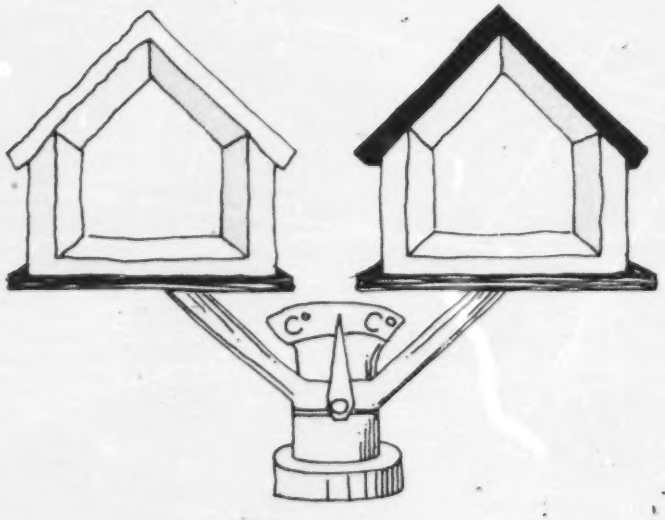
White, black, green, red and blue construction paper, all the same size

Timer

Uniformly-sized ice cubes

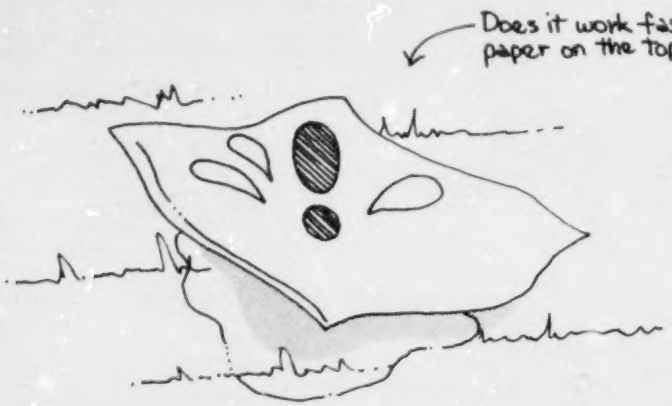


Place an ice cube on top of each sheet of construction paper. Which melts first?



Would a house with a white roof be cooler than a house with a dark roof ?

OTHER IDEAS TO EXPLORE:



Would you get the same results if the paper were on top of the ice cubes?

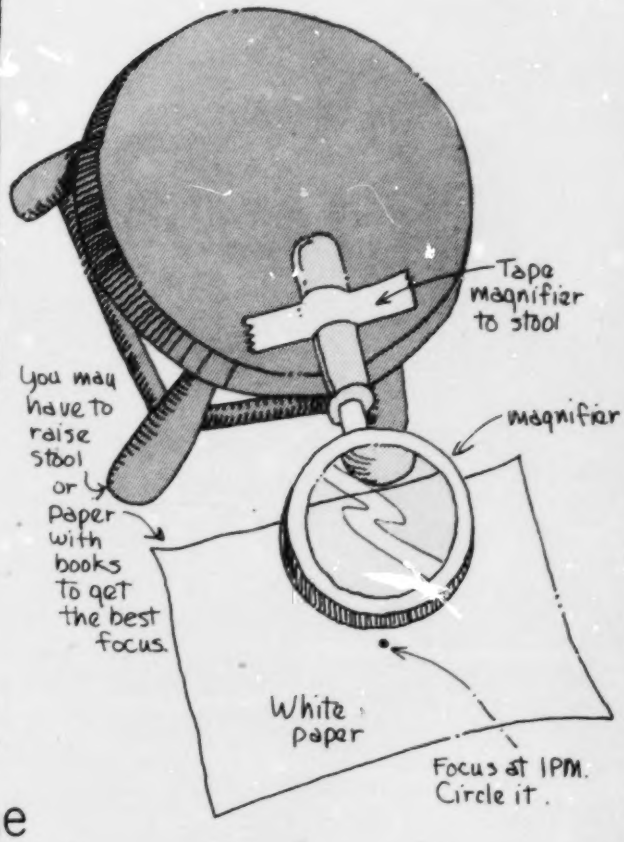
Would a house with a dark roof be more or less expensive to air-condition in the summertime?

HOW LONG WILL A MAGNIFYING GLASS FOCUS IN THE SAME SPOT AT 1 PM?

9

MATERIALS:

- 6 cm magnifying glass
- Chair or stool
- Masking tape
- Watch with second hand


Tape magnifier to stool
magnifier
You may have to raise stool or paper with books to get the best focus.
White paper
Focus at 1PM. Circle it.

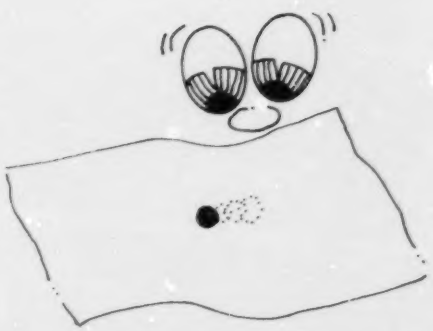
Adjust the lens to the best focus on a piece of white paper or cardboard. Mark its position at 1 pm by making a circle around the light. Measure the time it takes for the light to leave the entire circle.

How do the results of this experiment show how complicated it is to use reflectors and lenses for the collection of solar energy?

OTHER IDEAS TO EXPLORE:

Will the time it takes for the spot of light to move from the circle be the same if you try the experiment at 9AM?

How about 3PM?



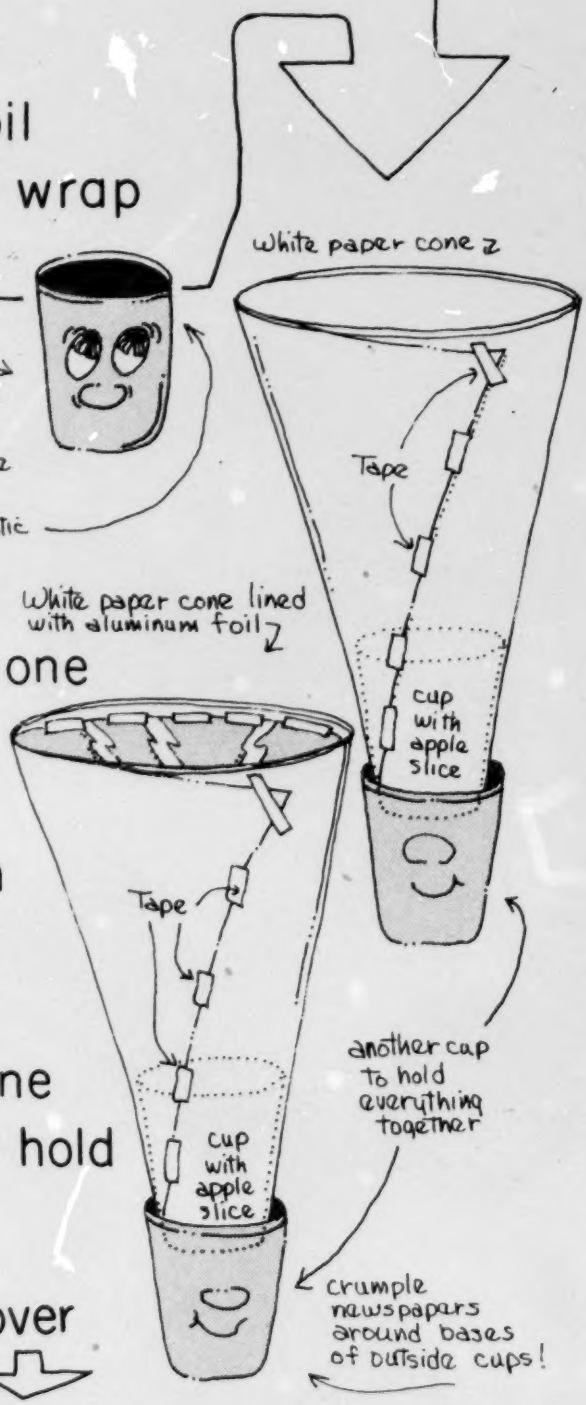
WHICH IS A BETTER -BAKER: A WHITE SUN COLLECTOR OR A FOIL COLLECTOR?

10

MATERIALS:

4 Paper cups — unwaxed
White paper, aluminum foil
Black paper, plastic food wrap
Scissors, newspaper

Line the inside of 2 paper cups with black paper,
then place a slice of apple in each cup.
Cover the cups with plastic food wrap tightly!


White paper cone
Tape
White paper cone lined with aluminum foil
cup with apple slice
Tape
another cup to hold everything together
cup with apple slice
crumple newspapers around bases of outside cups!

Then make 2 large cones — one with white paper lined with aluminum foil and one with white paper only. Wrap each around the apple cups.

Cover the bottom of each cone and cup with another cup to hold it together.

over

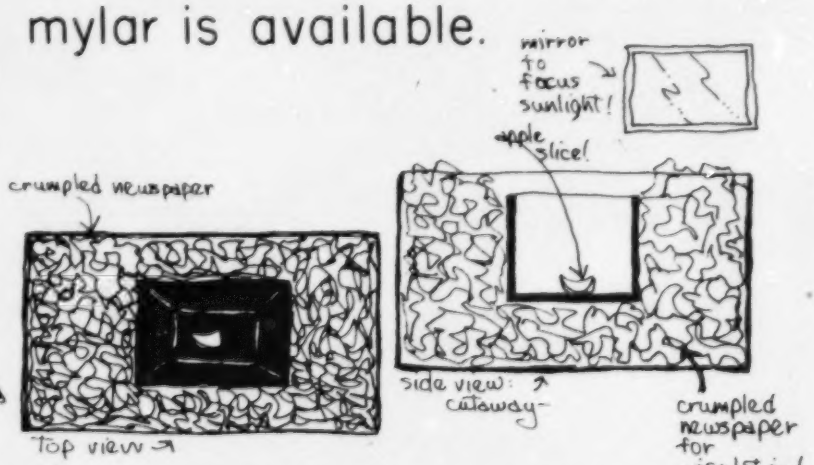
Aim the cookers at the sun.

When the apples look cooked, taste to see which was the better apple-baker.

OTHER IDEAS TO EXPLORE:

Repeat the experiment with other foods, such as a potato.

Try the experiment using mylar instead of aluminum foil, if mylar is available.

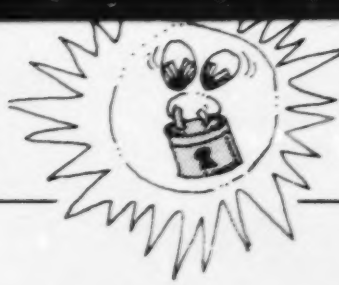


Use 2 cardboard boxes, 1 smaller than the other. Paint the inside of the smaller one black - do you know why? Put the small one inside the large one, and crumple newspaper to fill the space between them. Hold or tape a mirror in place to focus the sun's rays on the apple slice!

Another way to make a solar oven is by using mirrors.

(instructions above! ↑)

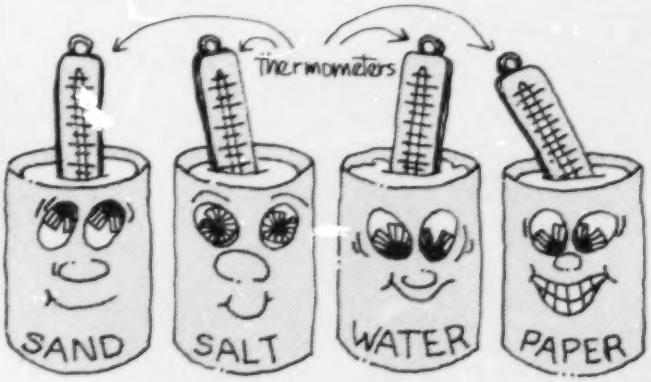
WHICH MATERIAL STORES SOLAR ENERGY THE BEST?

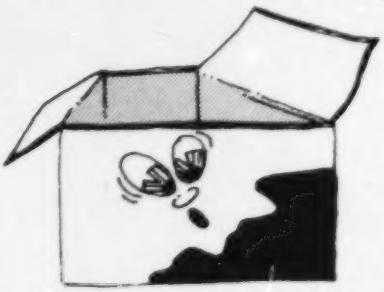


11

MATERIALS:

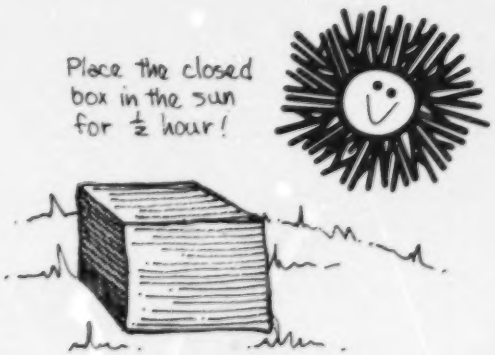
- Cardboard box
- Black paint
- 4 Small metal cans
- 4 Thermometers
- Sand, salt, water, and torn-up paper



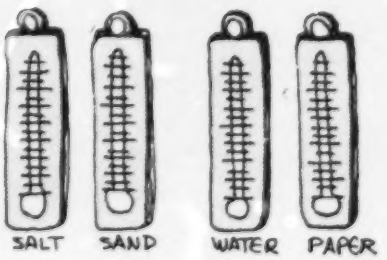


Fill the cans and place a thermometer in each one.

Paint the box black, and put the cans in the box.



Now remove the cans and watch the temperatures fall. Stir occasionally. Which temperature falls the slowest?



Which stores solar heat best?

HOW CLOSE TO A DO YOU HAVE TO PLACE A SOLAR CELL TO MAKE A MOTOR RUN AS FAST AS IT DOES IN SUNLIGHT?

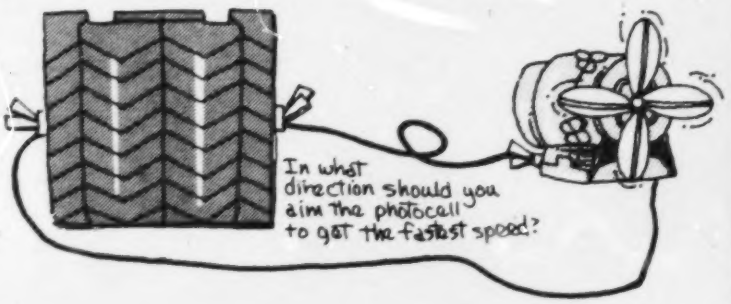
12

MATERIALS:

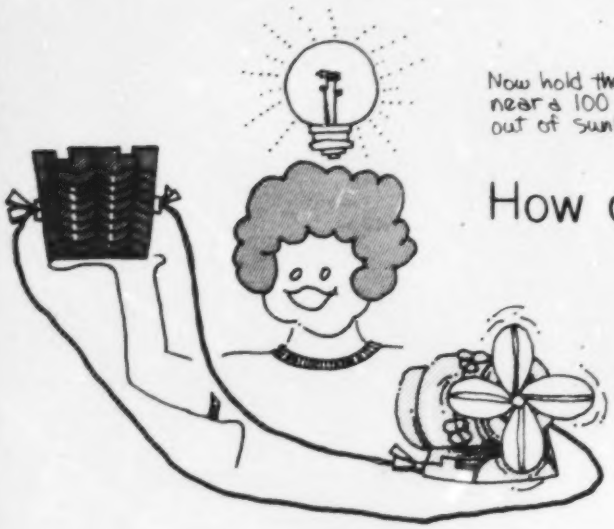
- Solar cell
- Motor with spinner disc
- Lamp with 100 watt bulb

Connect the solar cell and motor like this

Aim the solar cell out a sunlit window and notice how fast the motor turns.



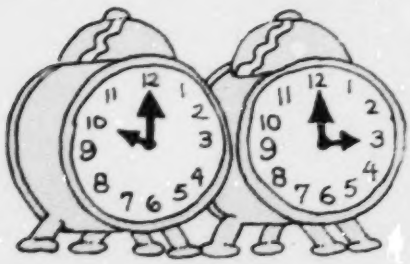
What would happen if the bulb were in a reflector? →



How close does the solar cell have to be to equal the energy from the sun?

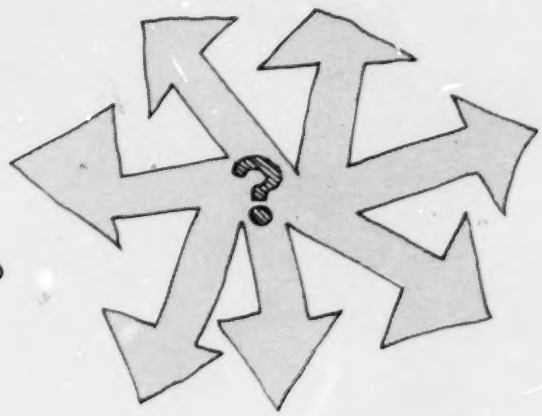
What happens if you use bulbs of different wattages?

OTHER IDEAS TO EXPLORE:



Try this experiment at other times, such as 10am and 3pm.

If you weren't allowed to move the solar cell during the day to follow the sun, what would be the best direction to aim it?



1. How much clean water can the sun get out of a pan of muddy water in a single day?

One of the possible uses of solar energy is to make pure water. Experiment number 1 shows how the heat of the sun speeds up the evaporation process, separating the condensation (water) from the sediment (dirt or salt).

2. How much faster can you burn a paper with a 6 cm magnifier that with a 3 cm magnifier?

One way to make effective use of solar energy is to concentrate the sun's rays through magnification. The focusing phenomenon is demonstrated in this experiment, as is the increase in concentrating power as the lens becomes larger.

3. In collecting solar energy, is bigger better?

Collecting solar energy is another important means of making use of the sun. This crude solar flat-plate collector shows how such collection systems work.

4. How long does it take to cook a hot dog with the sun?

This experiment with a simple solar cooker demonstrates the importance of concentrating solar energy precisely for maximum effectiveness.

5. How much warmer do things get in the sun than in the shade?

An experiment such as this with shade and direct sunlight gives an indication of the extent of the heat from the sun reaching the earth's surface.

6. How much weight can a grape lose in a week?

A traditional use of solar power is the drying and preserving of fruit through the reduction of their water content. Similarly, the sun can be used to extract salt from ocean waters (see experiment number 1).

7. How much hotter does a house get when the windows face south instead of north?

The position of a house on a lot relative to the sun's position is an important element in using the sun's energy to keep the house warm or cool.

8. What color absorbs the sun's heat best?

The color of a house and its roof affects dramatically the amount of heat soaked up by the house or reflected away from it.

9. How long will a magnifying glass focus in the same spot at 1 PM?

One of the impediments to the efficient use of solar energy is the perpetual movement of the earth and the consequent change in position of the sun in the sky. Such movement makes focusing for any significant length of time extremely difficult, requiring sophisticated and expensive magnifying instruments and other machinery.

10. Which is a better apple-baker: a white sun collector or a foil collector?

This experiment demonstrates the relative effectiveness of various materials in collecting heat and preventing it from escaping.

11. Which material stores solar energy the best?

One of the biggest problems of making widespread use of solar energy is finding ways to store it when the sun is not present. This experiment gives a clue to how such storage is accomplished.

12. How close to a light bulb do you have to place a solar cell to make a motor run as fast as it does in sunlight?

Converting solar energy directly to electricity is one of the most exciting new notions related to the use of the sun. This experiment shows how the process works.